The connection between on-farm assessed welfare (A-index) and production parameters of the sows.

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Tiivistelmä — Referat — Abstract

The aim of this study was to investigate connections between on-farm assessed welfare scores and production parameters of sows. Welfare was assessed using a Finnish on-farm assessment system, the A-index. Two different kinds of production data were used, both originating from the national herd surveillance database.

Welfare assessments were done on 30 commercial piglet, gilt producing and integrated farms during March 2007. One trained person did the scoring on all the farms visited. The A-index comprises of six categories: ‘locomotion’, ‘social interaction’, ‘floor quality’, ‘stable climate’, ‘feeding’ and ‘health and stockmanship’. Each category has 3-10 mostly environmental-based parameters that differ between different unit types. The maximum total score for a unit is 100. Scoring was performed separately in the farrowing, breeding and gestation sow units. The small number of independent breeding units (n=7) led to a combination of the breeding and gestation unit scores for dry sow unit; the averages are used for statistical analysis. Two production data used were 1) Farm record data (n=29), which is a basic data including farm and production parameters from the year preceding the on-farm assessment visit, 2) POTSI-data (n=30), where the production data are modified with the POTSI-application (MTT) so that the impact of management group (farm, year and season) can be seen. Connections were studied with correlation and regression analyses.

Although participation was voluntary in terms of production data systems the experiment farms represented the average Finnish farm. Total A-index points varied between 37,5-64,0 for lactating and between 39,5-83,5 for dry sows. Concerning the Farm record data the better A-index scores from ‘health and stockmanship’ category during lactation period shortened the reproduction cycle, decreased the percentage of stillborn piglets and increased the number of litters and piglets per sow per year. Regression models gave significant explanation value to ‘health and stockmanship’, when variation in the number of piglets per year, the length of farrowing interval and the number of farrowings before culling was explained. Better locomotion opportunities in dry sow unit had negative impact on the number of piglets born and weaned per year. Regression model gave significant explanation value to ‘locomotion’ and to percentage of first litters when variation in the number of weaned piglets was explained. With POTSI-data lower number of stillborn piglets was related with better ‘social interaction’ scores with gilts in farrowing unit and better ‘health and stockmanship’ scores with sows in dry sow unit.

The results from two production data differ from each other and it would be advisable to use Farm record data, with the production records from the whole year, for future studies on the subject.

Based on this experiment actions to improve animal welfare also have an economical impact as they enhance the production of the sows. Especially good quality stockmanship and healthier animals results in greater number of piglets born and shorter reproduction cycle. Special attention should be paid to minimizing the social stress and the success of feeding in group housed gestating sows.

Avainsanat — Nyckelord — Keywords

welfare assessment, on-farm assessment of welfare, production parameters, reproduction, sow

Säilytyspaikka — Förvaringsställe — Where deposited

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Muita tietoja — Övriga uppgifter — Further information

This experiment was a part of *Tuotantoeläinten hyvinvointi – tuottajien asenteet ja käytännöt* (Production Animal Welfare – farmer’s attitudes and practices) – project.

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Tiivistelmä — Referat — Abstract

Tämän tutkimuksen tavoitteena oli selvittää tilalla määritetyn hyvinvoinnin yhteyttä emakoiden tuotantotuloksiin. Hyvinvointia arvioitiin suomalaisen hyvinvointi-indeksin, A-indeksi, avulla. Tuotantotuloksina käytettiin kahta erilaista tuotosaineistoa, jotka molemmat pohjautuivat kansalliseen tuotosseuranta aineistoon.

Hyvinvointimääritykset tehtiin 30 porsastuotantosikalassa maaliskuun 2007 aikana. A-indeksi koostuu kuudesta kategoriasta ’liikkumismahdollisuudet’, ’alustan ominaisuudet’, ’sosiaaliset kontaktit’, ’valo, ilma ja melu’, ’ruokinta ja veden saanti’ sekä ’eläinten terveys ja hoidon taso’. Jokaisessa kategoriassa on 3-10 pääosin ympäristöperäistä muuttujaa, jotka vaihtelevat osastoittain. Maksimipistemäärä osastolle on 100. Hyvinvointimittaukset tehtiin porsitus-, tiineytys- ja joutilasosastoilla. Erillisten tiineytysosastojen pienen lukumäärän takia (n=7) tilakohtaiset tiineytys- ja joutilasosastopisteet yhdistettiin ja keskiarvoja käytettiin analyyseissä. Yhteyksiä tuotokseen tutkittiin kahden eri aineiston avulla 1) Tilaraportti aineisto (n=29) muodostuu muokkaamattomista tila- ja tuotostuloksista tilavierailua edeltävän vuoden ajalta, 2) POTSI-aineisto (n=30) muodostuu POTSI-ohjelmalla (MTT) muokatusta tuotantoaineistosta, joka sisältää managementtiryhmän (tila, vuosi, vuodenaika) vaikutuksen ensikoiden ja emakoiden pahnuekohtaiseen tuotokseen. Yhteyksiä analysointiin korrelaatio- ja regressioanalyysien avulla.

Vaikka osallistuminen tutkimukseen oli vapaaehtoista, molempien tuotantoaineistojen perusteella tutkimustilat edustavat keskituottoista suomalaista sikatilaa. A-indeksin kokonaispisteet vaihtelivat välillä 37,5–64,0 porsitusosastolla ja 39,5–83,5 joutilasosastolla. Tilaraporttiaineistoa käytettäessä paremmat pisteet porsitusosaston ’eläinten terveys ja hoidon taso’ -kategoriasta lyhensivät eläinten lisääntymissykliä, lisäsivät syntyvien pahnueiden ja porsaiden määrää sekä alensivat kuolleena syntyneiden lukumäärää. Regressiomallin mukaan ’eläinten terveys ja hoidon taso’ -kategoria selitti syntyvien porsaiden lukumäärän, porsimisvälin pituuden sekä keskiporsimiskerran vaihtelua. Paremmat pisteet joutilasosaston ’liikkumismahdollisuudet’ kategoriasta alensivat syntyneiden pahnueiden sekä syntyneiden että vieroitettujen porsaiden lukumäärää. Regressiomallin mukaan ensikkopahnueiden osuus ja ”liikkumismahdollisuudet” kategorian pisteet selittivät vieroitettujen porsaiden lukumäärän vaihtelua. POTSI-aineiston yhteydessä kuolleena syntyneiden porsaiden lukumäärän aleneminen oli ensikoilla yhteydessä parempiin porsitusosaston ’sosiaalisiin kontakteihin’ ja emakoilla puolestaan joutilasosaston parempiin ’eläinten terveys ja hoidon taso’ pisteisiin.

Kahden eri tuotantoaineiston avulla saadut tulokset erosivat toisistaan. Seuraavissa tutkimuksissa onkin suositeltavampaa käyttää Tilaraporttiaineistoja, joissa tuotokset ilmoitetaan vuosikohtaisina.

Tämän tutkimuksen perusteella hyvinvoinnilla ja tuotoksella on yhteyksiä, joilla on myös merkittävää taloudellista vaikutusta. Erityisesti hyvä eläinten hoito ja eläinten terveys lisäävät tuotettujen porsaiden määrää ja lyhentävät lisääntymiskiertoa. Erityishuomiota tulee kiinnittää vapaana olevien joutilaiden emakoiden sosiaaliseen stressiin ja rehunsaannin varmistamiseen kaikille yksilöille.

Avainsanat — Nyckelord — Keywords
Hyvinvointi-indeksi, emakoiden tuotos, hyvinvoinnin määrittäminen tilatasolla

Säilytyspaikka — Förvaringsställe — Where deposited
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Muita tietoja — Övriga uppgifter — Further information
Tämä tutkimus oli osa *Tuotantoeläinten hyvinvointi – tuottajien asenteet ja käytännöt*– projektia.
Ohjaajat: professori Anna Valros ja FM Tiina Kauppinen

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1. Introduction

Animal welfare, and especially pig welfare, has been a topic of public discussion during the last years in Finland and all over Europe. There is a constant pressure from the consumers towards better animal welfare through better housing conditions and to more transparent animal production. In the European Union the legislation for housing sows has been changed partly as a response to these opinions. From December 2012 onwards it is not allowed to house sows in breeding crates more than four weeks after weaning. It is still under debate if this action really improves the welfare of the sows, for example due to social stress and aggression between unfamiliar animals. To date, the greatest action on improving animal welfare and scientific knowledge and understanding of the concept of welfare is EU founded a project known as Welfare Quality® (between years 2004 and 2009). Project has worked on developing species-specific assessment systems to evaluate welfare on farms and at slaughterhouses which could be used to advice producers as well as to integrate animal welfare into the food quality chain. This work is a part of Finnish *Tuotantoeläinten hyvinvointi – tuottajien asenteet ja käytännöt* (Production Animal Welfare – farmer's attitudes and practices) - project that aims to investigate connections between animal welfare, producer attitudes and production parameters.

Animal welfare is a multidimensional concept that can be defined in different ways. The most common way to approach the concept of welfare are the five freedoms defined by Farm Animal Welfare Counsel (FAWC 1992) 1) freedom from hunger and thirst, 2) freedom from discomfort, 3) freedom from pain, injury or disease, 4) freedom to express normal behaviour and 5) freedom from fear and distress. On the other hand Appleby (1996) represents animal welfare as a state of well-being brought by meeting the physical, environmental, nutritional, behavioural and social needs of the animals under the care or influence of people. Husbandry and disease control that we consider to be suitable and meet the needs of an animal may satisfy physical, environmental and nutritional needs, but they may not guarantee the satisfaction of behavioural and social needs. Thus, special attention should be paid to these factors in intensive farming. Even researchers on the topic have different views about how animal welfare should be judged: 1) the view that animal welfare is achieved only when animal is able to express natural behaviour models typical to species, 2) the biological view explains animal welfare through health and satisfied biological needs, 3) the view that centres on the affective (i.e. emotional) state of the animal (Fraser 2003). Earlier it was thought that natural behaviour is not a part of animal welfare because animals have adapted to production environment, but now we understand how integral part some behaviours of the animal are and how they persist in domesticated environments (Edwards 2007). Nest-building for example is a true behavioural need in sows and they express the need to carry out this behaviour whether they have the material and space or not (reviewed by Barnett et al. 2001). The affective state of the animal has usually been assessed by measuring hormonal changes in animals or by observing abnormal behaviours (Edwards 2007). These measurements can be invasive or/and time consuming, and because of that, it is not reasonable to use them as a part on-farm welfare assessment. As a consequence it is important to have a profound knowledge about species' behaviour and reactions to different stimuli and situations from the experiments done in controlled environments before assessing on-farm welfare.

From mid-1990s onwards there has been a growing interest to develop scientifically proved measurement and assessment systems for animal welfare. Different kinds of methods have been used to compound a measurement system for animal welfare (reviewed by Botreau et al. 2007a). Measurement systems are often indexes comprised of several attributes that are summed together to form an index score. Attributes are often divided into different categories inside the index. Index and category points allow comparisons between assessed animal welfare situations/systems. Some of the indexes have been developed purely to assess animal welfare on farm or individual animal level to be used e.g. as an advisory tool. Others have been developed to certify organic farm systems or food labels (reviewed by Johnsen et al. 2001). For the assessment of on-farm animal welfare for pigs and especially for sows there were only a few systems developed and described in literature when this project started. One of the most widely used measurement systems is Animal Need Index (ANI) (in literature know also in German: Tiergerechtheitsindex "TGI") that has been developed by Bartussek in Austria since 1985. It has a basic version ANI-35 as well as a longer version ANI-35L with more measurement parameters (Bartussek 1999). In Germany Sundrum et al. (1994) developed a wider version based on Bartussek's work known as ANI-200. The numbers 35 and 200 refer to the maximum points of the index. A more complicated SOWEL (SOw WELfare) model was constructed in the Netherlands by Bracke et al. (2002b). All these models agree on which housing system (tethers, stalls, free range etc) is the best or the worst from the welfare point of view (Bracke et al. 2002a). Later the European Welfare Quality® project has created assessment systems for cattle, pigs and poultry to evaluate and monitor the quality of animal welfare on farms or at slaughterhouses (Kniering and Winckler 2009, Scott et al. 2009).

Welfare assessment can be done based on the animal or its environment. Environment-based measurements include e.g. space allowance, animal density and microclimate in the animal unit. (Word unit is used in this experiment for building or part of a building where the majority of animals in certain production phase are housed). Measurements of environment parameters are based on previously collected information about the effects that environment is known to have on the animal, but they can only identify conditions which could have impact on animal welfare and should not be used to predict animal welfare per se (Keeling 2005). Though environmental measurements can't give direct information on welfare of an individual animal they are widely used in on-farm welfare assessment systems because measurements can be done quickly and inter- and intra-observer repeatability is good (Napolitano et al. 2009). Animal-based measurements give more detailed information on the welfare state of the animal. As earlier mentioned traditional measurement systems based on, for example, blood sampling can not be used on large scale on-farm experiments. Human-animal interaction, abnormal behaviour, body condition score, skin and hair condition, lameness and injuries are animal-based measures used for welfare assessments on-farm. The main aim in the use of animal-based measurement with on-farm assessment is to find measures that have proved validity and reliability to be taken on a large number of animals in a reasonable time (Sevi 2009). Existing methods evaluate animal-based parameters 1) as a percentage of all animals in the same production phase (A-index, (Munsterhjelm et al. 2006)) or 2) detailed measures are done on randomly selected animals from the production phase of interest (Welfare Quality® (Scott et al. 2009)) as it would be impossible to evaluate all individuals on a farm.

In addition to the difference in measured parameters, assessment systems also differ in ways they aggregate the information collected. In a review of existing methods by Botreau et al. (2007a) assessment systems are divided into four categories by the way the data is processed: 1) data is analysed by expert(s) who draw conclusions on welfare, 2) data is compared with minimal requirements set for each measured parameter, 3) data is converted into ranks, which are then summed together to create a rank score for the farm, 4) data is converted into values or scores compounded in weighted sum or using ad hoc rules.

It is known that there is a connection between stress and welfare, and that stress can be a consequence of compromised welfare (Veissier and Boissy 2007). It is also known that stress has connections with health and reproduction problems. Stress is a situation where the animal can not adapt to stimuli and situations in its surroundings without major hormonal or behavioural adjustments. Problems with animal density (Hemsworth et al. 1986), social connections between animals (Einarsson et al. 1996), regrouping of the animals (Tsuma et al. 1996), feeding conditions (Arey and Edwards 1998), temperature (Einarsson et al. 1996) and stockperson (Hemsworth et al. 1986) have been found to be reasons leading to stress in sows. Recent studies have shown that stress has an impact on reproduction hormones and their function in pigs, but the changes have impact on reproduction only if the stress lasts for a substantial period (>4 days) (Turner et al. 2005). This is usually the situation on a farm level where the sows may need to endure different kind of stressors during their reproduction cycle. The impact of stress on reproduction is strongest during ovulation and heat (Turner et al. 2005). On an individual level stress can postpone beginning of the heat (Lang et al. 2003) and prevent heat symptoms (Brandt et al. 2006). Hormonal disturbances during the implantation and maternal recognition of pregnancy can increase embryo mortality and affect conception rate and litter size (van der Lende 1994). Also behaviour and hormonal changes during parturition and early lactation are sensitive to stressors which can have negative impact on piglet survival as reviewed by von Borrel et al. (2007)

Few studies have been made to evaluate the connection between on-farm welfare scores and different production parameters. The underlying problem here is the lack of one precise and accepted assessment system. Yet there are studies done comparing different assessment systems and health or behaviour data. Offner et al. (2003) revealed clear connections between the results of animal welfare assessments by the ANI-35L and animal health and behavioural parameters in dairy and suckling cows (11 farms), which they considered to be a good indicator of the validity of the system. Zaludik et al. (2007) found positive correlations between egg production of laying-hens (number of the flocks 164) and total ANI-35L scores and negative correlations between ANI-category points and featherless areas and total pecking injuries. With A-index, a modified version from ANI-35L and ANI-200, (Munsterhjelm et al. 2006) found positive connection between the high welfare scores and the number of piglets and litters per sow per year. Herva et al. (2009) established a positive correlation between the A-index score for beef cattle and daily carcass gain.

The A-index has been developed from the ANI35L-model (Bartussek 1999) and ANI-200 (Sundrum et al. 1994) in cooperation between Munsterhjelm et al. (2006) and A- Tuottajat (A-producers), which is a meat buying and producer consultative company in Finland. The A-index has been designed to be used especially in areas where year-round outdoor rearing is not possible due to extreme winter conditions. Most of the A-index points come from environment-based parameters and the data collected is analysed by compounding the weighted values together.

The aim of this study was to evaluate on-farm animal welfare and investigate its connection to production parameters of sows. The reasons behind the possible connections will also be discussed. The assessment of the connections between welfare and production was done using two different kinds of production data and their suitability for following experiments will be discussed.

2. Material and methods

2.1 Animal welfare assessment system

For on-farm welfare assessment A-index for dry sow units and farrowing units was used. Munsterhjelm et al. (2006) chose the ANI-35L-model as a base for the Finnish welfare index because it has been shown to work in extensive field use in Austria were it is used to evaluate and categorise organic farms (Bartussek 2000). Modifications had to be done concerning outdoor rearing that gives 20% of the points in ANI-models. In Finland outdoor rearing is seldom used because of the winter conditions and points for these categories were re-assigned to ‘stable climate’-category.

The A-index for dry sow units (breeding and gestation) is a modification from the Animal Need Index ANI-35L-model (Bartussek 1999). The wider German ANI-200 (Sundrum et al. 1994) was used to add a ‘feeding’-category for dry sows and to develop all new scoring for lactating sows with litters (Munsterhjelm et al. 2006). National pig protection legislation (FINLEX) served as a baseline for the A-index. In all parameters where the legislation could be referred to, meeting the demands of the legislation gives zero points (Munsterhjelm et al. 2006). In this experiment some parameters of A-index used by Munsterhjelm et al. (2006)

were divided to create more specific measurement parameters (divided parameters have the same upper index letter in Tables 1 and 2).

A-index for both units has six categories: ‘locomotion’, ‘social interaction’, ‘floor quality’, ‘stable climate’, ‘feeding’ and ‘health and stockmanship’. Each category is comprised of 3-10 parameters and the parameters differ between farrowing and dry sow (breeding and gestation) units (presented in Tables 1 and 2). Maximum score depends on how important this category or parameter is considered to be for the welfare of the animal. ‘Stable climate’ for example has been considered to have a bigger welfare impact on the animals in the farrowing unit than in the dry sow unit and for that reason the number of parameters is greater and they are weighted to give more points (max points 28 vs.16). The maximum score for all units is 100. Categories, measured parameters with the best and worst levels and point scales are presented in Table 1 and 2. Animal-based parameters are marked with an asterisk.

Table 1. A-Index for lactating sows according to Munsterhjelm et al. 2006

Categories	Best level	Worst level	Point scale
Locomotion			**max. 11**
Farrowing pen	Sows are able to turn around	Sows in crates all the time	3-2-1,5-0
Available pen area	>6m^2, sow is free	Sow in stall	2-1,5-1-0
Stalling of the sow	2-3 days pre partum or free sow	> 7 days pre partum	2-1-0
Separate activity areas in pen, sow	Three separate areas, free sow	No separate areas, sow in stall	2-1,5-1-0
Separate activity areas in pen, piglet	Feeding, resting, excretion	No separate areas	1-0,5-0
Rooting material	Bedding, >3cm	No	1-0,5-0
Floor quality			**max. 8**
Amount of bedding[a]	Bedding, all animals all the time	No bedding	2-1-0
Quality of bedding[a]	Straw	Other	1-0
Cleanliness of lying area, sow[b]	Clean and dry	Not completely	2-1-0
Cleanliness of lying area, piglets[b]	Clean and dry	Not completely	2-0,5-0
Quality of floor and slats	Good, non-slippery, slats < 11 mm	Not good	1-0,5-0
Social interaction			**max. 9**
Size of farrowing room	< 9 pens, only sows with litters	≥13, other pigs in room	2-1,5-1-0
Nestbuilding possibility	Free farrowing, >5cm material	Farrowing in stalls, no material	5-3-2-1-0
* Calmness of animals	Calm and curious	No	2-0
Stable climate			**max. 28**
Light regimen[c]	>100 lux, fluorescent lamp	40-100lux, reading is hard	1-0
Light period[c]	8-12 h/day	over 12 or under 8	1-0
Night light[c]	Yes, light bulb	No, nothing	1-0,5-0
Windows and natural light[c]	To north or possibility to cover	No windows	2-1-0
Effective temperature, sow	15-18°C	<15°C or >21°C	3-1,5-1-0
Effective temperature, piglets	28-32°C	Other	3-0
Floor heating for piglets	Yes, works	No	2-1-0
Creep box for piglets	Yes, draught free	No	4-2-1-0
Incoming air	Working, to dunging area, if hot to the resting area	Inadequate	3-2-1-0
Humidity[d]	50-80%	Other	2-0
Power of ventilation (m^3/sow/h)[d]	Good: >250	Inadequate: <180	2-1-0
Air quality[d]	Good, no gases or dust	Bad, gases and stuffy	2-1-0
Noise	<55 dB	>65 dB	2-1-0
Feeding			**max. 21**
Feeding regimen	Strictly followed plan	The feed is suitable for sows	2-1-0
Feeding times per day	4 or ab libitum	1-2	2-1-0
* Body condition score	>95 % in good condition	<90 % in good condition	3-2-0
Roughage	Yes	No	1-0,5-0
Litter equalization, milk substitute[e]	Yes	Occasionally or no	2-0
Creep feeding[e]	Creep feeding from 1 week of age	No, piglets are given dry feed before weaning	1-0,5-0
Water availability[f]	Free, feed can not cover drinking nipple	Free, feed can cover drinking nipple	2-0
Water flow, sows[f]	>4 liters/min	< 3 liters/min	5-4-0,5-0
Water flow, piglets[f]	<0,5 liters/min	>0,5 liters/min	1-0
Water temperature[f]	Pre-heated, 15-17°C	No preheating, or other	1-0
Health and stockmanship			**max. 23**
Hygiene of feeding and drinking equipment	Good: clean and dry	Moderate	2-0,5-0
Condition of pen fixtures	Good	Moderate	2-0,5-0
* Health of skin[g]	Good in >95% of animals	Problems with >30% of animals	1-0,5-0
* Health of claws and joints[g]	Good in > 95 % of animals	Problems with >30% of animals	2-0,5-0
Farrowing supervision	Always	No or occasionally	2-1-0,5-0
Teeth-clipping[h]	No	Clipping max. 1 week old	1-0,5-0
Castrating[h]	No	Castration max. 1 week old	2-1,5-0
* Culling	No chronically ill animals or runts present	No culling or runts in >10 litters	3-1-0
* Piglet mortality	<8 %	>23 %	7-5-3-2-1,5-1-0
Book keeping	Yes	No	1-0

a-h. Parameters marked with same upper index have formed one parameter in Munsterhjelm et al. (2006)
* Animal-based parameter

Table 2. A-Index for dry sows according to Munsterhjelm et al. 2006

Categories	Best level	Worst level	Point scale
Locomotion			**max. 21**
Pen	Group housing	Stall >4 weeks	2-1-0
Available solid floor area, sow[a]	>3 m^2/sow	<1,3 m^2/sow	2-1,5-1-0,5-0
Available solid floor area, gilt[a]	>2 m^2/gilt	<1,0 m^2/gilt	1-0,5-0
Area of deep litter	>3 m^2/sow	<1,5 m^2/sow	4-3-2-1,5-1-0
Separate activity areas in pen	Feeding, resting, excretion	No separate areas or stalls	2-1-0
Rooting material	Straw, hay or compost >5 cm	No	5-3-2-1-0,5-0
Body scratching possibilities	Brushes, corners, poles	No	1-0,5-0
Outdoor enclosures	Yes, with wallowing area and shade	No	2-1,5-0
Boar pens	>6 m^2 or >10 m^2 if used for mating	<6 m^2	2-0
Floor quality			**max. 12**
Bedding	Straw or straw and something else	No bedding	4-3-2-0,5-0
Cleanliness of lying area	Clean and dry for all sows	Not completely	2-1-0
Slipperiness of the floor[b]	Non slippery	Lying and resting areas slippery	1,5-1,0
Slats[b]	<2,5 cm or no slats	>2,5 cm	0,5-0
Quality of floor and slats[b]	Good, slats max. 20 mm	Not good	1-0,5-0
Solid floor m^2/sow[c]	>1,3 m^2/sow crate included	<1,3 m^2/sow crate included	2-0
Solid floor m^2/gilt[c]	> 0,95 m^2/gilt crate included	<0,95 m^2/gilt crate included	1-0
Social interaction			**max. 16**
Feeding system, sows[d]	Closing gate	Through >30cm per animal	3-1,5-1-1,5-0
Feeding system, gilts[d]	Closing gate	Through >30cm per animal	1-0,5-0
Separated compartments in pen	3 or more	None or stalls	1-0,5-0
Mixing of the sows[e]	Stable groups	Individual animals are brought to the group	2,5-1-0
Gilt introduction[e]	After farrowing, or in an own group	Before farrowing	2,5-1-0
Group size in 1st gestation month[f]	2-6 animals	1 or >12	1-0,5-0
Group size 2nd -3rd gestation month[f]	2-7 animals	1 or >100	3-2,5-1,5-0,5-0
* Calmness of animals	Calm and curious	No	2-0
Stable climate			**max. 16**
Light regimen[g]	>200 lux, bright	40-100lux, reading is hard	2-1-0
Light period[g]	12-16 h/day	8-10 h/day	1-0,5-0
Night light[g]	Yes, light bulb	No, nothing	1-0,5-0
Windows and natural light[g]	To north or possibility to cover	No windows	1-0,5-0
Effective temperature	17-22℃	<15℃ or >24℃	3-2,5-0
Incoming air	Working, to dunging area, if hot to the resting area	Inadequate	1,5-1-0,5-0
Humidity[h]	50-80%	Other	1-0
Power of ventilation (m^3/sow/h)[h]	Good: >150	Inadequate: <113	2-1-0
Air quality[h]	Good, no gases or dust	Bad, gases and stuffy	1,5-0,5-0
Noise	<55 dB	>65 dB	2-1-0
Feeding			**max. 16**
Feeding regimen	Strictly followed plan	The feed is suitable for sows	2-1-0
* Body condition score	>95 % in good condition	<90 % in good condition	3-1-0
Roughage	All the time, or 2 times a day	Feed has fibre	4-3-0
Animals/drinking place	max. 8	>10	2,5-1-0
Water flow[i]	>2 liters/min, water is free	<2 liters/min	3-0
Nipple height[i]	75-90 cm, if on the through <90 cm	other	1,5-0
Health and Stockmanship			**max. 19**
Hygiene of feeding and drinking equipment	Good: clean and dry	Moderate	2-1-0
Condition of pen fixtures	Good	Moderate	2-1-0
* Health of skin[j]	Good in >95% of animals	Problems with >30%	1-0,5-0
* Health of claws and joints[j]	Good in > 95 % of animals	Problems with >30%	2-1-0
* Limping, sitting[j]	Little: <5 % of animals	> 30 % of animals	2-1-0
* Other illnesses[j]	Little:<3% of animals, no mange	>5 % of animals	2-1-0
Sick pen	Bedded pen, not in other use	No	3-2,5-2-0
* Culling	No chronically ill animals present	Chronically ill sows present	2-0
Book keeping	Yes	No	1-0
* Farrowing rate	>90%	<75%	2-1,5-1-0,5-0

a-j. Parameters marked with same upper index have formed one parameter in Munsterhjelm et al. (2006)

* Animal-based parameter

2.2 Production parameters

Production parameters were received and analysed in two different forms. Both data were received from FABA (Finnish Animal Breeding Association) and are from the Finnish herd surveillance system database. Herd surveillance data is collected by the farmers.

2.2.1 Farm record data

Farm record data is a basic data that includes farm and production parameters. All parameters are presented as actual values per litter or per year. Farm record data was received from 29 farms from the year preceding the on-farm assessment visit. From this data parameters of interest are herd size, breed of the litter born, percentage of first litters, litters per sow per year (LSY), piglets per sow per year (PSY), weaned piglets per sow per year (WPSY), stillbirth rate (SB%), mortality of piglets from birth to weaning (MBW%), total piglet mortality (TM%), farrowing interval (FI), weaning to oestrus interval (WOI) and number of farrowings before culling. Munsterhjelm et al. (2006) used Farm record data to analyse connections between welfare and production.

2.2.2 POTSI-data

The other data had been processed with the POTSI-application (POrsastuotannon Tehokkuus SIkatiloilla; in English: Piglet production efficiency) that has been developed by MTT Agrifood Research (Serenius and Puonti 2004). The POTSI-data is based on herd surveillance data and it has been processed to create a tool for assessing the impact of farm management and stockmanship on fertility parameters. Modification of the data has been done by including fixed and random effects in the model so that the pure effect of management group on the fertility can be revealed. The fixed effects include breeding method, breed of the litter, parity number, age at first farrowing, weaning age and management group. The effect of the management group is contributed from farm, year and season attributes. Random effects include sows' breeding value, environmental effect of the sow and sire's effect. All values from this data are presented as differences between the number of piglets per litter. The value tells the impact of management group compared with Finnish average (average value is zero). Piglet mortality (PM) value -0,10 for example means that piglet mortality is 0,1 piglets less per litter than on an average Finnish farm. Parameters assessed from POTSI-data are the total number of piglets born (TNB), the number of stillbirths (NSB), the piglet mortality birth to weaning (PM) and the number of weaned piglets (WP). Production of gilts (primiparous) and sows (multiparous, 2+) are separated in POTSI-data. For gilts the POTSI-data is received from the previous year. If possible for sows the year is divided into three or six months long periods depending on the number of observations. At least 20 observations for one three or six month long period are needed to allow the division of the year into parts (Serenius 2004). POTSI-data was received from all farms participating in experiment.

2.3 Data collection

Welfare data was collected on 30 commercial piglet, gilt producing (breeding animals) and integrated (piglet & meat production) farms. Participation was voluntary and it was a part of the *Tuotantoeläinten hyvinvointi – tuottajien asenteet ja käytännöt* (Production Animal Welfare – farmer’s attitudes and practices) – project. Farms were located in southern and western Finland, the main pig production areas of the country. All the farms were visited once during March 2007, the maximum of two farms per day. Each farm visit included a welfare assessment, a producer interview and a discussion about the result of the welfare assessment. One trained person did the scoring on all the farms that were visited.

Scoring was performed separately in the farrowing, breeding and gestation sow units. Breeding and gestation units were combined in most of the farms (n=23). Because of the small number of independent breeding units, the unit scores (breeding and gestation) for dry sows were combined and the averages were used for statistical analysis. If a farm had multiple units for the same production phase that differed from each other (new vs. old), scoring was performed in both units and the average of these scores works as an A-index score for the unit (n=2 for farrowing unit). If scores from one parameter were missing, other points in the category were scaled so that the maximum score for the category remained the same. Scores were missing from the ventilation efficiency of dry sow units (n=6) because of the measurement difficulties and from the boar pen size (n=2) because one of the farms had no boar and the other one kept the boar always in a group pen with sows.

Body condition of sows in ‘feeding’ category was assessed with five point scale (0=thin, 5=fat). Animals were considered to be in good condition when body condition score of 3 or 4 was observed at least in 95 % of the animals. Assessment of the ‘stable climate’ was done using appropriate devices for the measurement of temperature, humidity, light intensity, noise and draught of air, indicator smoke was not used. Effective temperature was calculated as in Straw and Wilson (1985), with the addition of the impact of floor heating +5°C. The efficiency of ventilation (m^3/sow/h) was calculated with the following formula:

(total area of ventilation openings x air draught x 3600 sec/h) / number of animals

2.4 Statistical analyses

Statistical analyses were performed with PASW Statistics 18 (SPSS Inc., Chicago, Illinois, USA). Farm was considered as experimental unit and Farm record and POTSI-parameters as dependents.

To approach the normal distribution some modifications of the parameters were done. Outliers were removed based on normality test (Shapiro-Wilk) from farrowing unit’s category ‘health and stockmanship’ (n=1), dry sow unit’s ‘health and stockmanship’ (n=1), Farm record data’s WOI (n=1) and LSY (n=1) and also from POTSI-data’s TNB2+ (n=2) and PM2+ (n=1). Because TNB2+ and PM2+ are contributors of WP2+ corresponding values (n=3) were also removed from further analyses of the POTSI-data. The farrowing unit’s categories ‘locomotion’ and ‘floor quality’ and Farm record’s WOI were normalized with logarithmic conversions. Dry sow unit’s ‘locomotion’ category was normalized by a square root transformation. Based on the Shapiro-Wilk test, the Farm record parameter LSY was not normally distributed, but it is included in the analyses based on the visual examination of distributions and the less powerful Kolmogorov-Smirnov normality-test. Farrowing unit’s ‘social interaction’ and dry sow unit’s ‘floor quality’ categories were impossible to normalize and further analyses are performed with non-parametric tests.

When relationships between A-index scores and Farm record parameters of interest are examined the impact of herd size, breed of the litter born and percentage of first litters has to be controlled for by including them in the model. Herd size was normalized with logarithmic conversion. Breed was divided into two categories: mainly purebred (n=4) and mainly crossbred (n=25) litters. Because of the one missing farm in the Farm record data the distribution of farrowing unit's 'stable climate' had to be normalized by square root transformation.

Piglet mortality between birth and weaning is assigned points in the welfare assessment of farrowing unit. Points for piglet mortality were removed from 'health and stockmanship' category and total scores when relationship with Farm record's WPSY, MBW% and TM% as well as PM/PM2+ and WP/WP2+ from POTSI-data was analysed. Farrowing rate is assigned points in breeding and gestation units and points from it were removed when assessing relationships with LSY, PSY, and WPSY from Farm record data. Farrowing rate points do not need to be removed when working with POTSI-data, because production data is for one litter only.

The assessment of relationships between A-index scores, Farm record data and POTSI-data were performed with correlation and regression analyses. Connections between A-index scores and Farm record data were studied with the partial correlation method, to control for the impact of number of animals, breed of the litter born and percentage of first litters. Pearson Correlation Coefficients was used for Farm record data. The connections between A-index scores and POTSI-data were also assessed with Pearson Correlation Coefficients and with Spearman's rho when non-parametric analyses were needed. If dependent (total unit points or category points) had more than two correlations ($p<0,05$) with production parameter further analyses were performed with linear regression. The herd size, breed of the litter and percentage of first litters were entered into to the model when regression analyses were done with Farm record parameters. Collinearity of predictors was analysed with correlation analysis to prevent the negative impact of multi-collinearity. Two predictors with correlations > 0.70 were not included in to the same model. According to Menard (1995) "A tolerance of less than 0.20 is cause for concern; a tolerance of less than 0.10 almost certainly indicates a serious collinearity problem." No predictors with tolerance value less than 0,1 were included in the analyses. The assumptions for regression analysis were checked with the normal distribution test (Shapiro-Wilk) to residuals and by assessing graphical information (histogram and P-P plot of regression standardized residuals) from residuals. Only results from models with normally distributed residuals are reported.

3. Results

3.1 Farm parameters

Four of the farms had free farrowing for all the sows. A majority of the farms kept gestating sows housed loose, either in deep litter (n=11) or without bedding (n=5). Fourteen farms kept the sows in crates for breeding and only four also after that. Only five of the farms had no problems with the terms of animal protection legislation. Most of the farms had problems with the light period and intensity, especially in the farrowing unit. There were also problems with the boar pen sizes especially when it was used also for mating purpose.

Combined A-index points from farms are presented in Table 3. Dry sow units had better total welfare scores than farrowing units (Figure 1) and the variation was grater in dry sow unit scores. There is a positive correlation between dry sow and farrowing unit total scores 0,474 (p-value 0,008), and also between 'locomotion' categories 0,404 (p-value 0,027).

Table 3. A-index scores from experiment farms

	Average	Minimum	Maximum	SD
A-index, farrowing unit (max. 100)	**50,9**	**37,5**	**64,0**	**6,6**
Locomotion (max. 11)	3,5	0,5	10,5	2,9
Floor quality (max. 8)	6,4	3,0	8,0	1,4
Social interaction (max. 9)	4,0	2,0	5,5	0,8
Climate (max. 28)	11,8	7,0	18,0	3,3
Feeding (max. 21)	12,8	6,5	19,0	3,4
Health and stockmanship (max. 23)	12,4	9,0	16,0	2,0
A-index, dry sow unit (max. 100)	**63,1**	**40,0**	**83,5**	**10,8**
Locomotion (max. 21)	8,2	1,5	17,5	5,0
Floor quality (max. 12)	8,7	4,5	12,0	2,5
Social interaction (max. 16)	9,8	5,0	13,0	2,1
Climate (max. 16)	7,5	4,0	14,3	2,4
Feeding (max. 16)	12,3	7,0	16,0	2,7
Health and stockmanship (max. 19)	15,3	12,5	17,5	1,3
A-index, farm score (max. 200)	**113,0**	**77,5**	**140,0**	**15,3**

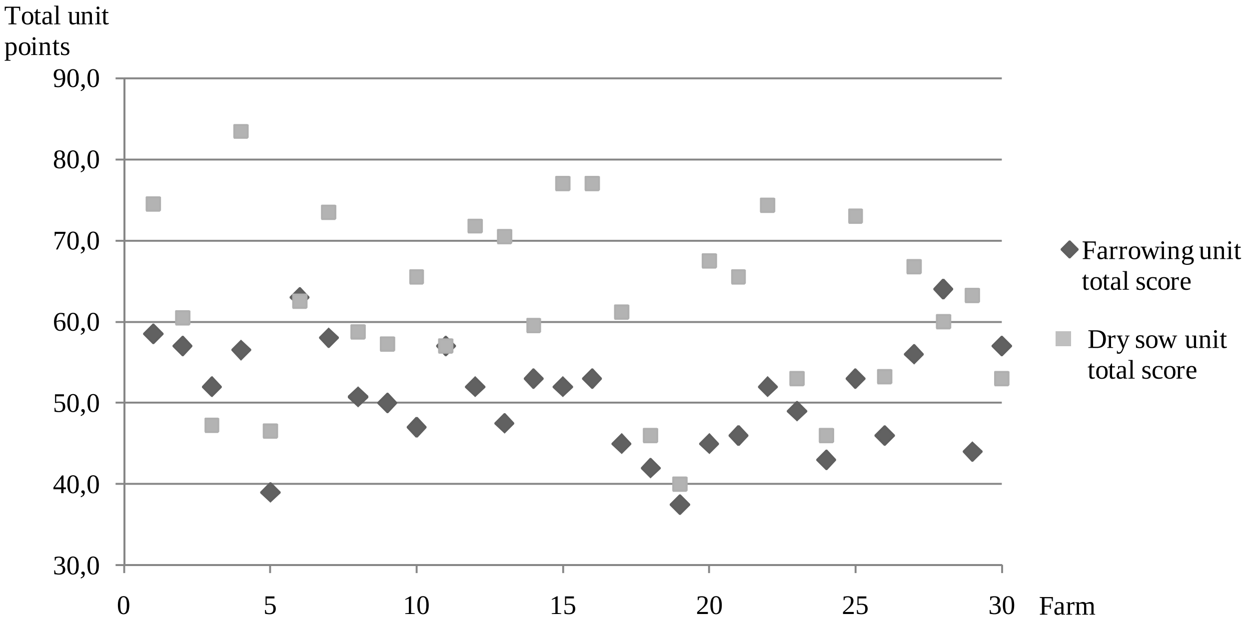

Figure 1. Total unit points from experiment farms

3.2 Production parameters

In regard to production parameters from the year 2006 farms participating this study represented the average Finnish farm (Table 4, FPRS06). When looking at the POTSI-data (Table 5.) farms seem to be below the average Finnish farms. For gilts, the total number of piglets is 0,1 piglets less than the average, the number of stillbirths and piglets died between birth and weaning is higher and there are less weaned piglets. For sows, the number of piglets born per litter is above average, but mortality remains higher and the number of weaned piglets per litter is below the average.

Table 4. Farm record data and Finland averages from Finnish Production Recording Scheme 2006 *(FPRS06)*

	Average	Minimum	Maximum	SD	*FPRS06*
Sows/herd	79,7	46,8	164,2	29,6	*71,4*
Parity	3,5	1,4	4,9	0,8	*3,5*
Litters/sow/year	2,1	1,4	2,4	0,2	*2,1*
Piglets/sow/year	26,6	16,4	31,9	3,5	*24,8*
Piglets weaned/sow/year	21,0	12,4	25,7	3,4	*19,7*
Stillbirth rate-%	8,7	2,8	12,8	2,2	*9,0*
Piglet mortality birth-weaning-%	13,6	6,1	24,9	4,2	*12,9*
Total piglet mortality-%	21,2	13,8	31,9	4,6	*20,7*
Farrowing rate-%	71,1	35,8	88,8	15,0	*72,2*
Farrowing interval	164,6	152,0	186,0	7,8	*170,0*

SD- standard deviation

Table 5. POTSI-data from experiment farms

	Average	Minimum	Maximum	SD
TNB (n=30)	-0,10	-2,49	2,33	1,20
NSB (n=30)	0,15	-0,66	1,35	0,42
PM (n=30)	0,13	-0,90	1,82	0,58
WP (n=30)	-0,39	-3,83	1,94	1,28
TNB2+ (n=26)	0,18	-0,63	1,05	0,46
NSB2+ (n=28)	0,04	-0,86	1,12	0,39
PM2+ (n=27)	0,12	-0,73	1,62	0,58
WP2+ (n=25)	-0,03	-1,97	1,05	0,77

SD- standard deviation, TNB-total number of piglets born, NSB- number of stillbirths, PM-piglet mortality, WP-weaned piglets, TNB2+-total number of piglets born 2+litters, NSB2+- number of stillbirths 2+litters, PM2+-piglet mortality 2+litters, WP2+-weaned piglets 2+ litters

3.3 Farm record data and A-index

Litters per sow per year (LSY) increase with better scores from farrowing unit's 'health and stockmanship' category and decreased with higher points in dry sow unit's 'locomotion' category. In addition to this, points in 'locomotion' category in both units have negative connection to the number of piglets born per sow per year and via this also to WPSY. PSY is positively correlated with the farrowing unit's 'health and stockmanship' category. The

Table 6. Correlations between Farm record parameters and A-index scores

	LSY (n=28)	PSY	WPSY	SB%	MBW%	TM%	FI	FBC	WOI (n=28)
Farrowing unit									
Total score							-0,391†	-0,361†	
Locomotion		-0,347†	-0,426*						
Stable climate							-0,486*		
Health and stockmanship	0,561**	0,528**		-0,491*			-0,449*	-0,487*	-0,463*
Dry sow unit									
Locomotion	-0,383†	-0,403*	-0,451*		0,367†	0,347†			
Feeding								-0,469*	-0,385†
Health and stockmanship								-0,433*	

** $p<0{,}01$, * $p<0{,}05$, † $p<0{,}1$

LSY-litter per sow per year, PSY-piglets/sow/year, WPSY-weaned piglets/sow/year, SB%-stillbirth rate, MBW%- mortality birth-weaning, TM%-total mortality, FI- farrowing interval, FBC- farrowings before culling, WOI-weaning to oestrus interval

percentage of stillbirths decreases if farrowing unit's 'health and stockmanship' points increase.

There is also a connection between 'locomotion' scores in dry sow unit and mortalities, both MBW% and TM%. Farrowing intervals shorten with farrowing unit's increasing points in total score, 'stable climate' and 'health and stockmanship'. Farrowing times before culling are negatively linked with A-index scores. Because of the small number of the farms also nearly significant correlations with p-value <0,1 are reported with other correlations in Table 6.

Farm record parameters PSY, WPSY, FI and FBC have multiple significant correlations with index categories and further analyses are done with linear regression method, results in Table 7. The assumptions for regression analysis are met in all dependent and predictor parameters. All together regression analyses have good coefficient of determination values (R^2, the proportion of the variance in the dependent explained by the independent parameters). PSY increases with increasing 'Health and stockmanship' score, a one-point-rise in scores results in 0,637 piglets more per sow per year. Other predictors in the model are statistically non-significant, but the model explains 70,2% of the variation in PSY. The percentage of first litters and 'locomotion' score in dry sow unit lower WPSY, one point rise in 'locomotion' score results in 1,213 fewer weaned piglets per sow per year. The model explains 57,2% of the variation in the number of WPSY. Farrowing interval shortens 1,354 days if 'health and stockmanship' score rises one point. The regression model explains 66,5% of the variation in farrowing interval. For FBC, the following regression equation can be written:

FBC=9,456-0,863 (if litter crossbred) -0,116 x percentage of 1.litters -0,132 x health&stock.(dry sow)

Other predictors have non-significant impact on FBC, but the model still explains 75,4% of the variation in FBC.

Table 7. Results of regression analyses

	PSY R^2=0,702 p(F) <0,001		WPSY R^2=0,572 p(F)=0,000		FI R^2=0,665 p(F)=0,001		FBC R^2=0,754 p(F)=0,000	
Parameter	B	SE	B	SE	B	SE	B	SE
Constant	25, 12**	8,056	29,24***	7,249	202,78***	18,992	9,46***	1,868
Number of animals	-1,88^{NS}	3,041	1,34 ^{NS}	3,195	-2,39 ^{NS}	7,234	1,62*	0,713
Breed	3,18^{NS}	2,038	-0,21 ^{NS}	1,796	-7,52 ^{NS}	4,297	-0,86*	0,391
Percentage of 1. litters	-0,14 ^{NS}	0,096	-0,31*	0,085	0,37 ^{NS}	0,221	-0,12***	0,020
Total score (Farrowing)					-0,13 ^{NS}	0,229	-0,02^{NS}	0,016
Locomotion (Farrowing)	-1,26 ^{NS}	1,580						
Stable climate (Farrowing)					-3,75 ^{NS}	3,197		
Health and stockmanship (Farrowing)	0,64*	0,269			-1,35*	0,622	-0,13*	0,059
Locomotion (Dry sow)	-0,701^{NS}	0,510	-1,21*	0,505				
Feeding (Dry sow)							-0,04^{NS}	0,042
Health&stockmanship (Dry sow)							-0,16^{NS}	0,080

NS- non-significant, * p<0,05 **p< 0,01 ***p<0,001
PSY- piglets per sow per year, WPSY- weaned piglets per sow per year, FI- farrowing interval, FBC- farrowings before culling, R^2- coefficient of determination value, B- regression coefficients, SE-standard error

3.4 POTSI-data and A-index

Two significant correlations were observed between the POTSI-data and welfare scores. Both correlations represent connection to number of stillborn piglets. Increasing points in farrowing unit category ‘social interaction’ decreases the number of stillbirths in the first litters. Farms with better scores from dry sow unit’s ‘health and stockmanship’ category had fewer stillbirths in 2+ litters. There are no correlations between the total farm score and POTSI parameters. Regression analysis was not performed with POTSI-data. All found correlations are reported in Table 8. Also correlations that are nearly significant (p<0,1) are reported.

3.5 Connection between Farm record-data and POTSI-data

There are two correlations between Farm record data and POTSI-data: piglet mortalities between birth to weaning (PM and MBW% cor. 0,422 p-0,022) and number of weaned piglets from multiparous sows (WP2+ and WPSY cor. 0,591 p-0,001). There are no other connections found and the correlations between production parameters and A-index scores differ from each other.

Table 8. Correlations between POTSI- and A-index scores

		TNB	NSB	PM	WP	TNB2+ (n=28)	NSB2+	PM2+ (n=28)
Farrowing unit	Total score (piglet mortality points excluded)							0,379†
	Floor quality	-0,314†						
	Social interaction^{NP}		-,407*					
	Stable climate							0,359†
	Health and stockmanship				0,337†			
Dry sow unit	Total score			-0,348†				
	Social interaction			-0,338†				
	Health and stockmanship					-0,392†	-,392*	

* p<0,05, † p<0,1; NP- non parametric (Spearman)
TNB-total number of piglets born, NSB- number of stillbirths, PM-piglet mortality, WP-weaned piglets, TNB2+-total number of piglets born 2+litters, NSB2+- number of stillbirths 2+litters, PM2+-piglet mortality 2+litters

4. Discussion

The objective of this study was to observe possible connections between animal welfare and production, and to assess these connections. Significant connections do exist though correlations are moderate. The regression models result in equations with high coefficient of determination values (R^2), this might partly be due to the large number of explaining parameters included in the models. On-farm assessed welfare has connection with Farm record production parameters and especially better animal health and stockmanship during lactation period seem to shorten the reproduction cycle. Better locomotion opportunities have negative impact on the number of piglets produced and weaned per year. The two different production data differed both from each other and in the way they correlated with the A-index scores.

4.1 Farm record data

Several different categories of the A-index were connected to the reproduction parameters of sows. Farms participating in this experiment had similar A-index total scores to those in the study by Munsterhjelm et al. (2006). However, the observed connections between A-index scores and production parameters are not similar. This could be due to the variation in category points received in these experiments or possible error sources discussed later in this chapter.

4.1.1 Locomotion in the farrowing unit

In the farrowing unit, there was a negative connection between locomotion opportunities for the sow and PSY and WPSY. Connections could be explained by the free movement of the sows and crushing of piglets connected to it, incidences that have been observed for example by Marchant et al. (2000). Weber et al. (2007) observed that there was no connection between free movement of the sows and total piglet mortality on the farm. Free sows did crush more piglets, but piglets from the crate sows died with other reasons, resulting in equal total mortality (Weber et al. 2007). In this experiment, the crushing of the piglets is not the reason behind the lowered number of weaned piglets because there is no connection between 'locomotion' scores and piglet mortality parameters MBW% and TM%. The factors behind this connection remain unclear and the connection might be purely a result from a small sample size.

4.1.2 Health and stockmanship in the farrowing unit

The number of PSY increased with better ‘health and stockmanship’ scores in the farrowing unit. Based on the regression analysis this category was the only significant factor influencing the number of piglets born per sow per year. The increase in category scores has association to greater number of litters born per year and lower stillbirth rate. High scores result from clean and working environment and from healthy animals, deriving from good work motivation and management. High motivation and good professional skills are probably also connected with good reproduction management. Also Munsterhjelm et al. (2006) observed the connection between ‘health and stockmanship’ and greater number of LSY and PSY, although in the gestation unit.

‘Health and stockmanship’ in a farrowing unit was also connected to the length of the reproduction cycle and to the number of litters per year. Better scores had positive impact on LSY, FI and WOI. These parameters may be connected to each other as shorter WOI may also result in shorter FI and greater LSY. Still shorter weaning to oestrus interval does not guarantee a successful breeding, implantation and gestation. The shorter FI and WOI can be achieved with better sow health at weaning time. Points in ‘health and stockmanship’ come partly from better skin and leg health. Bonde et al. (2004) established a connection between poor body condition and lameness and body (shoulder) lesions. Nutritional deficiency during lactation results in delayed oestrus (Prunier et al. 2010). Low quality of stockmanship was connected to decreased production, as reviewed by Hemsworth et al. (2009) and it could be assumed that disinterest in animal health would also play a role in longer FI and WOI observed in farm with lower points in the ‘health and stockmanship’ category.

Farrowing supervision is also assigned points in ‘health and stockmanship’ in the farrowing unit, this is probably where the connection to a lowered stillbirth rate derives from. All in all the better observation skills and the interest towards the animals seem to enhance the productivity of the farm.

4.1.3 Stable climate in the farrowing unit

'Stable climate' in the farrowing unit was correlated with FI even though connection was not seen in the regression analysis. In 'stable climate' good points are achieved when conditions are ideal for piglets and at the same time sow is not stressed with too warm conditions. In addition ventilation and lighting parameters are measured. A longer lighting period has been observed to have positive impact on sows' appetite during lactation period (Prunier et al. 1994). As a result weaning to oestrus interval might shorten but the direct impacts of long light period and various light intensities on weaning to oestrus interval are contradictory (reviewed by Prunier et al. 1996). High ambient temperatures lower sows' milk production, body reserve mobilization and appetite reducing feed intake, which in turn delays oestrus after weaning (Prunier et al. 1997) and thus lengthens the farrowing interval. Factors affecting weaning to oestrus interval have generally more influence on primiparous sows (Prunier et al. 1996), but the data we used does not differentiate between primiparous and multiparous animals.

4.1.4 Locomotion and feeding in the dry sow unit

The negative impact of 'locomotion' scores in the dry sow unit on piglets born and weaned per year could be caused by the group housing and stress connected to it. Social stress during key times of the reproduction cycle will result in suppressed oestrus behavior, reduced ovulation rate and increased embryo mortality (Arey and Edwards 1998). This is why individual housing during early pregnancy (<4 weeks) has been considered better in terms of production parameters (Munsterhjelm et al. 2008) but also contradictory (Bates et al. 2003) or neutral (Tsuma et al. 1996) results have been reported (reviewed by Kongsted 2004). The differences in results could be explained by great variation in how the group housing is performed and what kind of group dynamic has been in practice in different experiments. The results by Kongsted (2006) suggest that the most important factor reducing the reproduction in group housed sows is the unwanted variation in feed intake. The A-index considers feed intake and probability of satisfaction with six parameters, but they are located in three different categories ('locomotion', 'social interaction' and 'feeding'). As a consequence it is not possible to assess the connection between the reduced piglet production and the success of the dry sow feeding on the farms. Munsterhjelm et al. (2006) observed a positive connection between 'feeding' category points in dry sow unit and total litter size. In this study the ‘feeding’ category in the dry sow unit had a tendency to correlate with WOI, suggesting that better scores shorten the weaning-to-oestrus interval. Even though this category does not include all parameters connected to a successful feeding does, highlight the importance of feeding in dry sow unit.

The variation in feed intake has an impact both on the animal receiving too little feed and on the animal receiving too much feed. The impact of feed deprivation is most crucial with gestating gilts because immature as they are, they are dividing the energy and nutrients between their own growth and the pregnancy (Whittemore 1996). Sows receiving too much feed have better body reserves, which lowers appetite during lactation, which in turn may lead to an excess weight loss and longer weaning-to-oestrus interval (Coffey et al. 1994). High feeding levels during early pregnancy have been shown to result in increased embryonic mortality mediated by changes in hormonal (progesterone) concentrations (den Hartog and Vesseur 1994) Overweight sows are also more likely to have problems with leg health (Prunier et al. 2010)

Freer movement of the animals during pregnancy could be assumed to reduce stillbirth rates through better muscular health and easier parturition, but in this experiment this kind of connection was not observed. There was a tendency to moderate positive correlations between ‘locomotion’ category scores in dry sow unit on piglet mortalities, both MBW% and PM%. Based on these results no new information can be added to previous experiments in the subject of gestation housing systems impact on piglet mortality parameters. Sows housed loose during pregnancy have been reported to have better control over their movements in farrowing cages compared with sows housed in stalls and better muscular activity may also help them avoid crushing the piglets (Boyle et al. 2002). On the other hand loose housed sows may feel farrowing cages more restrictive and they make more posture changes during parturition and lactation period (Boyle et al. 2002). All posture changes are dangerous to the piglets (Marchant et al. 2001) and may lead to crushing the piglets.

4.1.5 Farrowings before culling

The negative connections between welfare scores and the number of farrowings before culling are an interesting factor and might have connections with producer attitudes towards animals.

More about this will hopefully be revealed when the project concerning farmer's attitudes and practices is ready. It could be thought that the farmers who make the effort on animal welfare may also have lower threshold when deciding on culling of the sick animals. More information would have been revealed if the connections between removal reasons and welfare scores could have been assessed, but this was not possible due to the poor data collection on the reasons for removals.

4.2 POTSI-data

Two significant correlations were observed between the number of stillbirths and A-index categories. During parturition most of the piglet mortality is caused by prolonged farrowing (Oliviero et al. 2010) and farrowing difficulties both causing increased risk of asphyxia (lack of oxygen) of the piglets. The environment has an influence on the behaviour of the sow and to duration of farrowing (Oliviero et al. 2008). Farrowing is also prolonged if the litter is big (Cutler et al. 2006) or there are malformed and/or dead piglets in the litter (van Dijk et al. 2005).

Some of the results with POTSI-data are coincidence due to the small number of farms. The negative connection between the total number of piglets born for gilts and 'floor quality' in the farrowing unit can only be explained by coincidence. Usually, gilts have not spent time in farrowing unit in advance and the total number of piglets born can not be influenced by the floor quality approximately week before farrowing.

4.2.1 Social interaction in farrowing unit

With gilts, the results show that a smaller and calmer farrowing unit, receiving nest building material and calmness of the animals help to lower the number of stillbirths. The calmness of the animals was observed as their reaction to an unknown person (assessor) entering the unit. Janczak et al. (2003) reported prolonged parturition and a tendency to have more stillborn piglets with gilts expressing high fear on humans. On the other hand Hellbrügge et al. (2009) observed the negative connection between the explorative response to humans and the number of stillbirths in gilts. Especially in gilts, the nest building behaviour has been reported to shorten the process of parturition (Cronin et al. 1993) and to lower the number of stillborn piglets (Thodberg et al. 2002). In this experiment there is no connection between 'social interaction' category and stillbirths in sows, probably due to their habituation to the parturition situation. Compared with the second parity sows increased environmental sensitivity has been observed in gilts (Thodberg et al. 2002).

4.2.2 Health and stockmanship in dry sow unit

The number of stillborn piglets in sows was negatively correlated to the scores from the dry sow unit's 'health and stockmanship' category. One explanation could be a higher quality of stockmanship and a greater interest in the animals, which in turn could have a positive impact on noticing farrowing difficulties and a decreased threshold to take actions when problems are noticed. Lowered stillbirth rate can also be explained through easier parturition of healthier and fitter sows. In the dry sow unit, the animals' health and quality of stockmanship are assessed with animal-based parameters including skin and leg health (Table 2.) and problems with these factors might impact sows' performance during parturition. Also the occurrence of diseases can influence the number of stillbirths as there are several diseases which can cause embryonic and fetal deaths (Givens and Marley 2008). This connection is not present in gilts, which could result from overall better leg and skin health observed in gestating gilts than sows, as well as from the fact that with increasing parity, the odds for piglet mortality during the gestation period and the parturition itself increases (Mulley and Edwards 1984).

4.3 Production parameters

Two different kinds of production parameter data were used, Farm record and POTSI-data, to assess their suitability for comparable studies. As they both come from the national herd surveillance database where the information is collected by the farmers the reliability of the collected information may create a problem and has to be checked before analyzing.

The Farm record parameters from the national herd surveillance database are commonly used in Finnish field studies when connections on production parameters are studied (Peltoniemi et al. 1999, Munsterhjelm et al. 2006, Hälli et al. 2009). Factors known to have impact on reproduction parameters are used as control variables when Farm record data is studied. For instance Munsterhjelm et al. (2006) used herd size, breed and percentage of first litters as control variables where Hälli et al. (2009) used herd size, parity and farrowing rate. The choices are made based on the subject studied and known biological connections. In this experiment breed of the litter born was used instead of breed of the sow, because in the Farm record data breed is informed only from sows that are farm tested for breeding value and this information was missing from part of the sows on some farms. In addition, when breed of the litter is used as control variable also the possible impact of sire is included (Serenius et al. 2003).

There are no other experiments using POTSI-data to assess the connections to production. The use of POTSI-data could be reasoned with the modifications that have been done on fertility parameters (Serenius and Puonti 2004, Serenius et al. 2004). The modifications remove a majority of the factors having such an impact on reproduction that the impact of interest might remain latent. POTSI-data comprises the impact of farm, year and season. The impact of these factors is remarkable as can be seen from the difference in the result between the two production parameter data. Also the separation of the production between primiparous and multiparous sows increases the informational value of POTSI-data. The first problem with POTSI-data lies with the fact that it is based on production per litter. The variation in fertility parameters between litters exist especially when the impact of season is not removed. Late summer and early autumn are the seasons when fertility parameters consistently show the lowest values indicative of a 'seasonal infertility period' (Peltoniemi and Virolainen 2006). The second problem is the difference in time scale from which the data is received (Serenius 2004). In this study, the results from larger piggeries are from periods of three or six months. From smaller piggeries and from gilts the results are from the whole year preceding the visit.

It would be more advisable to use Farm record data when connections between production and on-farm measured welfare are assessed. The equal measurement intervals for all farms and greater number of reproduction cycles give more reliable parameters. The farms have to be carefully selected to avoid the use of farms with varying quality in data collection. Unfortunately careful selection of the test farms contradicts with the principles of random sampling. Also the variables that need to be controlled for should be selected based on their known impact on (re)production parameters.

POTSI-data offers a valuable advisory tool for farmers as it gives direct information on the impact of management on fertility at the period of interest.

4.4 Possible error sources

There are multiple factors that might have had an impact on results in this study and that need to be considered when conducting further research on this topic.

4.4.1 Small sample size

The relatively small sample sizes in this study (Farm record n=29, POTSI-data n=30) and uneven distributions of different housing systems make it impossible to do further statistical analyses by dividing the farms into free farrowings vs. crate farrowings or by time spent in breeding crates. With further analyses it could have been studied whether the connections we found really do result from the factors discussed earlier in this chapter. Sample size in this study ($n \leq 30$) is also considered to be small in the linear regression analyses and may lead to a high standard error (SE) -values. In this experiment, the SE -values are relatively high when compared to regression coefficients.

4.4.2 Reliability

To be used in the scientific experiments assessment system needs to have a certain level of reliability. Reliability can be measured and judged as 1) inter-observer reliability when the assessment system is used by different assessors (Napolitano et al. 2009), 2) intra-observer-reliability when the same assessor does repeated evaluations under the same circumstances (De Rosa et al. 2003, Burn et al. 2009) and 3) test-retest reliability, when the same tests are repeated with the same subjects (De Rosa et al. 2003). The different reliabilities of A-index have not been tested and all together there is a paucity of information on the reliability measurements and threshold values of welfare assessment protocols (Knierim and Winckler 2009). Most of the A-index points come from the environment-based parameters that are known to have better valuation reliabilities (Knierim and Winckler 2009). Intra-observer variation is not a problem with environment-based parameters that result from direct measurements and based on this it can be assumed that assessment accuracy did not vary between farms when assessment was done using A-index. The inter-observer biases are not a source of error in this experiment as all the measurements were done by one assessor. Reliability can be improved by refining definitions; the division of the certain parameters used by Munsterhjelm et al. (2006) was done to clarify the parameters assessing multiple factors.

4.4.3 Measured parameters

Nearly all the parameters assessed in the A-index are environment-based. Even though environment-based parameters have been widely used on welfare assessment systems they are now receiving a lot of criticism concerning their ability to assess welfare (Bracke 2007). The later developed systems, from Welfare Quality®-project for example, are focusing mainly on animal-based parameters, since they are believed to give more reliable information on an animal’s actual welfare. Also these new systems use environment-based measures if animal-based measures are not sensitive, valid or reliable enough (Welfare Quality® consortium, Lelystad, The Netherlands 2009). Environment-based parameters can be justified with better reliability and their usefulness in the on-farm assessment of welfare. Bracke (2007) poses some critical points with measured parameters 1) animal-based measures can not be interpreted without the knowledge of underlying environment factors 2) animal-based measurements may not be able to assess certain things with known negative impact on welfare e.g. lack of social connection, space and foraging substrate. Animal-based parameters reveal the level of welfare at the time of the measurement; they can not be used to evaluate welfare in the long run. According to Bracke (2007) the available knowledge between the connections of environment- and animal-based parameters should be used when making inferences on welfare.

The best assessment system would be a combination of animal- and environment-based parameters, combined with parameters assessing the quality of stockmanship and management on the farm. The A-index evaluates stockmanship with multiple parameters. Yet, with these parameters it is not possible to assess the nature of animal-stockperson interaction or the level of fear that animals have towards humans. Measures like this might predict the level of stress experienced by the animal during standard procedures on the farm (Hemsworth et al. 1986). The attitudes and practices of the stockperson definitely have an impact on the animals, especially in a small family farms, such as the majority of the farm in this study, where only one person might by responsible for all handlings of the animals. Besides having the impact on stockpersons' behaviour attitudes also affect the promptness of actions when problems with welfare arise (Hemsworth et al. 2009).

4.4.4 The use of weighted sum

With the A-index, the results are compounded with the weighted sum method. Measured parameters (pen areas, the % of animals) are assigned points on scale. These points are weighted so that they reflect the parameters' impact on animal welfare. Though the weighted sum method is widely used in animal welfare assessment (Sundrum et al. 1994, Bartussek 1999, Bracke et al. 2002b) some problems do exist. Some information is always lost when actual values are converted into scaled points. Still these conversions to uniform scales have to be made to allow any kind of summing of the measured parameters to produce a welfare score or to do statistical analyses of the results. Weighted sums may allow compensation between some welfare scores (Botreau et al. 2007a) which might conflict with the multidimensional nature of welfare (Botreau et al. 2007b) as the animals are not able to unambiguously compensate between their needs. This compensation might happen inside the category, if different parameters compensate each other, or between categories. A farm that receives average scores in all the categories is probably better from a welfare point-of-view than a farm that receives good scores in three categories and zero points in the rest. This can be one cause behind the fact that no significant connections between total farm or total unit scores and production parameters were found in this experiment or the experiment by Munsterhjelm et al. (2006). Though the method has its down-sides, it produces absolute scores for the farm, which make comparisons between farms and farming systems possible (Botreau et al. 2007a).

4.4.5 Problems with animal protection legislation

In the A-index there is a problem with the fact that farms meeting the demand for zero point do not differ from the farm that would score below zero if such a score would be possible. Ideally, this should not be a problem as the need to score below zero means that the terms of animal protection legislation are not met, but only five of the farms met all the terms. This may have an impact on results as the lack of negative points makes it impossible to see the true difference between the farms in the worst end of the point scale. Excluding the farms with deficiencies was impossible due to the small number of farms participating in this study and to the high proportion of farms with some or multiple deficiencies.

4.4.6 Lack of control

On-farm assessed animal welfare experiments have been criticized for the lack of control over the conditions in the experiment farms (Edwards 2007). Though in intensive farming animals are usually kept under controlled environment, seasonal and climatic factors may impact the measurements done on the farm. In this experiment, all the farms were visited during one month to minimize the impact of changing seasons. During the spring months weather conditions change rapidly in Finland, it might be -10ºC during the night and over 10ºC during day time. This kind of fluctuation in outdoor temperatures causes extreme pressure on the ventilation system of the production buildings and the temperatures and ventilation might need manual adjusting. These manual adjustments made it difficult to measure air conditioning parameters on some of the farms. In the future, it could be recommended to time the farm visits to summer or winter months so that the outdoor temperature fluctuation is minimal. Another obvious problem with on-farm assessment method is the lack of control over the true circumstances on the farm. All the farms volunteered and knew the assessment date beforehand.

5. Conclusions

The level of on-farm assessed welfare has connections to the production parameters of sows. Better health of the animals and high quality of stockmanship have a positive impact on the piglet production parameters as well as on the length of the reproduction cycle. Not only did the farms with healthy animals and good stockmanship produce more litters and piglets per year, they also had lower stillbirth rates. With a connection also to the shorter weaning-to-oestrus and farrowing interval the efforts made on welfare do pay off economically. The influence that skilled and motivated farmers have on animal welfare can not be underestimated and parameters evaluating those factors should be included into the assessment systems that don not measure animal welfare directly from animals, in other words to systems that include environment-based parameters.

The problems connected to the group housing of the gestating sows are derived from several sources. Lowered piglet production in sows that have better locomotion opportunities is caused by social stress in groups, aggressions between unfamiliar sows and variations in feed intake. The change in legislation aiming to improve the welfare of sows will actually do so only if an effort is made to minimize the negative and hostile interactions between animals. Special attention should be paid when introducing gilts into the groups of older sows. The challenges of successful feeding in group housing systems were emphasized also in this study. The feeling of hunger and frustration in restrictedly fed gestating sows can be eased with adding fibre to the diet and offering roughage to animals.

Assessing welfare in a scientific manner will never be an easy subject, as the concept is loaded with different values and interpretations. Assessing on-farm welfare is even more complicated, as the parameters should be sensitive, valid and reliable, and at the same time measurement efficiency and speed should be at reasonable level. When assessing the connection between on-farm welfare and production parameters the sample size should be over 30, farms not meeting the terms of legislation should be excluded from the study and the control over the factors analysed and information collected should be kept as high as possible. For future studies more animal-based parameters should be included in the assessment system and even more importantly the methods for assessing the impact of the stockperson on welfare should be developed. Reliable assessment of welfare with a suitable assessment system is the only way to improve, keep track of and certify animal welfare in a way that satisfies both the researchers and the farmers as well as the consumers.

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